PB-229 695

REPORT ON WATER RESOURCES STUDY HURON RIVER BASIN MICHIGAN. A STUDY OF POTENTIAL NEEDS AND VALUE OF WATER FOR MUNICIPAL INDUSTRIAL, AND WATER QUALITY CONTROL PURPOSES

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

August 1963

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WATER RESOURCES STUDY
HURON RIVER BASIN
MICHIGAN

A Study of Potential Needs and Value of Water for Municipal Industrial, and Water Quality Control Purposes

By
U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region V
Chicago, Illinois

To
U. S. DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Detroit, Michigan

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NATIONAL TECHNICAL
INFORMATION SERVICE

56

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I. INTRODUCTION

Authority

The District Engineer, U. S. Army Engineer District, Detroit, Michigan, by letter of October 10, 1961, requested the U. S. Public Health Service "...to evaluate the water supply and water pollution aspects of the Huron River Basin and to prepare a report indicating the needs and the economic evaluation of these needs." It was also requested that the report include a specific evaluation of waters that might be developed in the proposed Mill Creek Reservoir.

Authority to conduct such studies is provided in the Federal Water Pollution Control Act (Public Law 84-660, as amended by Public Law 87-88 in 1961) and in the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to the Water Supply Act of 1958 (Title III of P.L. 85-500, as amended by P.L. 87-88).

Purpose and Scope

This study assesses municipal and industrial water supply needs in the Huron River Basin, assesses surface water quality control needs, and estimates need for and value of water storage for regulation of Huron River streamflow for these purposes to year 2010.

Acknowledgments

The conduct of a study of this type depends principally upon the cooperation of Federal, State, and local authorities in the region studied.

The assistance and support provided by individuals and the following agencies are gratefully recognized:

U. S. Geological Survey

Michigan State Department of Health

Michigan State Water Resources Commission

Wayne County Department of Public Works

City of Detroit Water Board

Detroit Metropolitan Area Regional Planning Commission

Washtenaw County Health Department

Ann Arbor Department of Public Works

Ypsilanti Department of Public Works

Ypsilanti Township Water Department

II. SUMMARY AND CONCLUSIONS

Summary

1. The Huron River Basin drains an area of 892 square miles in an important and fast-growing section of southeastern Michigan. Within the Huron River Basin, the Ann Arbor-Ypsilanti area is the primary area of concern in terms of municipal water supply use and water quality control problems.

2. The current municipal water use in the Ann Arbor-Ypsilanti area is about 17.6 mgd. One-third of this amount is taken from the Huron River and the remainder from ground sources. Industrial water uses total about 5.6 mgd; 4.6 mgd of which is withdrawn from surface sources, the remainder from wells.

3. Communities and industries within the basin discharge their treated and untreated wastewater to the Huron River or its tributaries, resulting in severe pollution problems in some reaches of the stream. At present, waste loads from the Ann Arbor-Ypsilanti area reaching the stream after treatment are equivalent in terms of BOD to the untreated sewage from a community of 12,000 persons.

4. While the quality of the Huron River is generally good, the discharge of wastes in the Ann Arbor-Ypsilanti area causes seasonal variation in quality which limits the use of the river for some purposes. Adverse quality has caused problems in water treatment and has discouraged use of the stream as a source of municipal water supply. Fish and aquatic life have been damaged, recreational uses curtailed, and the aesthetic enjoyment of the stream reduced.

Conclusions

1. The 1960 population of the Huron River Basin was about 240,000. It is expected to increase to 540,000 by 1985 and 985,000 by 2010. The major part of the population is in the Ann Arbor-Ypsilanti area where about 135,000 presently reside. This is expected to increase to 395,000 by 2010.

2. Municipal water supply needs for the Ann Arbor-Ypsilanti area are expected to increase from about 17.6 mgd at the present time to 52.4 mgd by 2010. At present about 11.7 mgd is taken from wells and the remainder from the Huron River.

3. Ground water sources in the vicinity of Ann Arbor-Ypsilanti can supply about 20 mgd and the Huron River, as regulated at Barton Lake, can be relied on for about 16 mgd. Therefore, existing sources of supply are inadequate to serve the area's needs in 2010.

4. Two primary sources of municipal and industrial water supply are available to the area. The selection of a source to meet future needs depends upon the long-range plan the area elects to satisfy its municipal and industrial water supply. Future municipal and industrial water supplies can be developed from (a) ground and surface sources within the basin, or (b) imported supplemental supplies from sources outside the basin. In either case, the method or means of disposing of the resulting wastes must also be considered. If surface sources within the basin are selected it is estimated that 13,000 acre-feet of storage will be needed for municipal and industrial water supplies to meet needs in 2010. Based on the cost of the most reasonable alternative source, it is estimated that the value of storage for municipal and industrial water supplies is at least equal to

the cost of a single-purpose reservoir at the Mill Creek site, Since the time of first need is approximately 1990, this value has been discounted at 3 percent to present worth for an annual benefit value of $76,000 to year 2010.

5. Storage is needed for flow regulation for surface water quality control in the Huron River below Ann Arbor. Existing natural Huron River streamflow considered dependable for waste assimilation purposes and the maintenance of surface water quality is 30 cfs. Present flow needs for the maintenance of surface water quality in the critical,warm, summer months are about 50 cfs based on the provision of adequate waste treatment. Maximum streamflow needs are expected to increase to 120 cfs by 1985 and 200 cfs by 2010, if the area continues to discharge waste treatment plant effluents to the river.

6. An alternate to discharging treated wastewater to the Huron River is to intercept wastes that can be economically collected from the Ann Arbor-Ypsilanti area by sewers leading outside the basin for subsequent waste treatment and discharge to a large body of water. Therefore, storage needs for quality control in the Huron River depend upon whether the area elects to (a) continue to discharge treated wastes to the river or (b) intercept collectable wastes, thereby decreasing wastes reaching the stream.

7. Various means of providing for future water supply needs and maintaining acceptable stream quality are available. Regardless of the long-range plan adopted by State and local agencies, there will be need for water storage upstream from Ann Arbor. The time of first need and quantity of storage for municipal and industrial water supplies or for quality control depend upon the plan selected.

8. The value of the benefits attributable to the provision of storage in Mill Creek Reservoir for municipal, industrial and/or quality control purposes has been evaluated in terms of the cost of single-purpose projects which would most likely be used in the absence of the multiple-purpose reservoir. The value of the benefits range from $100,000 per year if storage is provided for quality control needs and additional water supply needs are derived from outside the basin and collectable wastes are diverted from the basin to $269,000 per year if both water supply and quality control needs are met by provision of storage within the Huron River Basin. The alternatives are covered in detail in Section VII of the report.

9. Regardless of the plan selected for providing water supply and quality control, provision of quality control storage in Mill Creek Reservoir will benefit the health and well-being of residents of the Huron River valley and increase the value of the stream for all legitimate purposes.

10. Water quality monitoring would aid in regulating streamflow for quality control and would also supply data for further planning of water quality activities.

III. DESCRIPTION OF PRELIMINARY PROJECT LOCATION

The Mill Creek Basin is presently being considered by the Corps of Engineers as a possible site for a reservoir project (see Figure IV). This basin was selected on a tentative basis, pending studies of various needs for storage and estimates of benefits that would be realized, should storage be provided in this basin. This does not necessarily eliminate consideration of other reservoir sites until such time as the points or areas of need have been determined.

The Mill Creek tributary becomes confluent with the Huron River at the town of Dexter, which is about 8 miles upstream from Ann Arbor. Mill Creek watershed is about 135 square miles in area. The average flow of record of Mill Creek near Dexter is about 68 cfs. Minimum flows in the summer season have been as low as 2 cfs. Even though there are no water quality data available on Mill Creek, it is reasonable to assume that the stream will be of good quality, since this watershed is presently rural in character and is expected to remain so within the study period to 2010.

Preliminary analyses indicated about 20,000 acre-feet of storage could be provided by a dam in the general area shown in Figure IV and further that this is approximately the storage needed to maintain a minimum streamflow of 120 cfs in the Huron River at Ann Arbor under drought conditions. A refinement of storage needed to yield various flow schedules at a given dependability is contained in this report.

IV. DESCRIPTION OF BASIN

General

The Huron River Basin is located in the southeastern part of the lower peninsula of the State of Michigan. The basin drains parts of seven counties: Ingham, Jackson, Livingston, Oakland, Monroe, Washtenaw, and Wayne. As shown in Figure IV, most of this 892-square-mile basin is contained within the counties of Oakland, Livingston, Washtenaw, and Wayne. The Huron River discharges to Lake Erie at Point Mouille, which is located about 5 miles below the mouth of the Detroit River. Huron River is about 125 miles long and has a total fall of 430 feet of which 70 percent occurs in the upper basin above the city of Ann Arbor.

For about 50 miles from the mouth of the Huron to Ann Arbor the basin is narrow and averages 5 miles in width. Above Ann Arbor the basin fans out irregularly to form the upper basin, covering an area of approximately 711 square miles, or about 80 percent of the total basin area. The upper basin contains some 340 lakes and impoundments.

Portage River and Mill Creek are the two principal tributaries of the Huron River. Portage River drains a 79-square-mile area and joins the Huron at river mile 76, as measured along the course of the Huron from Lake Erie. Mill Creek watershed is about 135 square miles in area and joins the Huron at the city of Dexter at river mile 58.

The upper basin topography is rolling hills, flatlands, and lakes, and contains extensive deposits of sand and gravel. The terrain below Ann Arbor is relatively flat, containing primarily clay and silt deposits.

Seven hydroelectric dams have been constructed on the main stem of the lower Huron and two on the upper portion. Most of these dams were built prior to 1920 by the Detroit Edison Power Company and the Ford Motor Company. Hydroelectric power production has diminished in importance in this area as opposed to other sources of electric power. This trend has continued to the point where the Detroit Edison Company is considering liquidating its holdings of this kind.

Hydrology

The average annual precipitation in the basin is about 30 inches. Annual precipitation has been as high as 40 inches and as low as 20 inches. Generally, minimum precipitation occurs in February and maximum in May.

The average annual flow[1] of the Huron River at Ann Arbor for 55 years of record is 445 cubic feet per second (cfs) for a 711-square-mile drainage area. Maximum and minimum average monthly flows have been about 3,000 cfs and 21 cfs, respectively. The minimum daily discharge at Ann Arbor has been less than 10 cfs. The minimum 7-day average discharge with a once-in-10-year recurrence frequency is about 30 cfs.[2] The comparable 30-day average discharge is about 40 cfs.

Since the upper basin contains many natural lakes and swamplands plus porous soils, its storage capacity has been considered, in large part, responsible for the sustained flow characteristics of the lower Huron River. However, the general regimen of the stream is somewhat altered by lake-level control and hydroelectric operations (see Table 1). Table 1 shows tabulations of approximate flow times through main stream impoundments in the lower basin for 30 and 120 cfs.

Table 1

Huron River-Lower Basin Flow Time Through Ponds

Huron River Mile	Name of Impoundment	Pond Area (acres)	Volume (acre-ft)	Length (miles)	Time of Passage at 30 cfs (days)	Time of Passage at 120 cfs (days)
48	Barton Lake	310	3,600	4.0	61	15.2
46.5	Argo Lake	106	542	2.0	9	2.3
41.5	Geddes Lake	292	1,242	2.4	21	5.2
39	Superior Lake	109	625	2.1	10	2.6
37.5	Paper Mill Lake	72	362	1.1	6	1.5
32	Ford Lake	1,050	16,504	3.8	278	69.5
25.5	Belleville Lake	1,425	18,377	7.2	308	77.0
	Total	3,364	41,252	22.6	693	173.3

Water Quality

The surface and ground waters throughout the basin are moderately hard. In 1957 surface water above Ann Arbor was found to contain the concentrations of coliform, phosphates, and chlorides shown in Table 2.[3] In August of 1957 BOD values in Barton Lake, immediately above Ann Arbor, ranged from a low of 1.10 mg/l to a high of 2.62 mg/l. During the same period BOD values ranged from 2.93 mg/l to 5.52 mg/l at Ypsilanti, about 17 miles downstream. The streamflows for August 1957 were above average, however, and the D.O. associated with the aforementioned BOD tests were all above 6 mg/l.

Ground water is the primary source of water supply in the basin. Most of the wells draw from glacial drifts.[4] Ground waters are generally softened and the iron removed before use. Commercial softeners are commonly employed on individual domestic supplies. Some fresh water is available from the bedrock but the supply is meager, especially in the lower basin. Bedrock pumping rates in excess of recharge make it difficult to maintain quality since the underlying aquifers are high in chloride content. Unfortunately, those areas within the basin requiring large water supplies are, for the most part, located in the lower basin where the long-time safe yield of ground water is relatively low.

Table 2

Huron River Quality Above
Ann Arbor in 1957

Month	Average Daily Flow (cfs)	Mean Coliform Density (MPN/100 ml)	Average Concentration of PO_4 as P (mg/l)	Average Concentration of Chlorides (mg/l)
Oct.	180	45	0.140	7.8
Nov.	258	135	0.097	8.2
Dec.	375	110	0.105	9.1
Jan.	312	165	0.143	9.6
Feb.	445	1,100	0.056	9.3
Mar.	566	780	0.060	9.4
Apr.	649	110	0.180	7.8
May	613	160	0.232	7.2
June	409	160	0.112	7.4
July	574	100	0.172	7.9
Aug.	214	61	0.125	9.7
Sept.	245	56	0.365	8.0

V. ECONOMY

The Huron River Basin lies entirely within the metropolitan complex of Detroit, Flint, Saginaw, Lansing, Jackson, and Ann Arbor, Michigan. Five million people reside within a 50-mile radius of the center of the upper basin. An area with a radius of 100 miles would add the metropolitan areas of Bay City, Grand Rapids, and Kalamazoo, Michigan, and Toledo, Ohio, an additional 2.5 million population.

The rapidly expanding industrial base of the surrounding metropolitan areas has exerted a favorable impact on the Huron River Basin. The region has experienced rapid population growth.[5] During each of the last 5 decades, the combined growth of the six Standard Metropolitan Statistical Areas in and adjacent to the basin has exceeded the average growth rate of metropolitan areas in the nation. Since 1930 the population of the basin has been increasing at nearly twice the rate for the surrounding metropolitan ring. The major influence on the basin's economy has emanated from Detroit.

Employment in all of the subareas of the Huron River Basin has grown rapidly during the last several decades. In the Ann Arbor-Ypsilanti area employment in the manufacturing of motor vehicles dropped 2,000 or 33 percent from 1950 to 1960, but employment in other manufacturing industries increased from 6,400 to 11,000 during the same period. The change has resulted in a more balanced manufacturing base. The greatest growth rate was in noncommodity employment, particularly education. The provision of services accounted for 70 percent of total employment in 1960.

The population growth of the basin is expected to continue at a rapid rate, influenced by many of the same factors that have operated in the past.* As economic and cultural facilities expand in response to population growth and the demand for goods and services increases, areas of relatively low density adjacent to production and market centers will be favored. The past population growths of the principal communities in the Huron River Basin are shown on Table 3. Population projections for the Huron River Basin and related areas are shown on Table 4.

In 1960 population of the entire Huron River Basin was about 240,000. By 1985 it is expected to reach 540,000 and by 2010, approximately 985,000. Past population increases have been largely in the Ann Arbor-Ypsilanti area. From the foregoing study the population of the Ann Arbor-Ypsilanti area is expected to reach 395,000 by year 2010 as shown in Figure I.

---

*The methodology employed in making the projections entailed an analysis of various indices and trends: (1) ratio of growth in population between the nation, State, the surrounding metropolitan complex, Detroit SMSA and the basin, (2) trends in population density, (3) trends of employment in the major industrial segments, (4) comparative population growth rate during the last 5 decades with every other metropolitan area of comparable size in the nation, and (5) comparison with recognized published projections.

Table 3

Population of Principal Communities
in the Huron River Basin

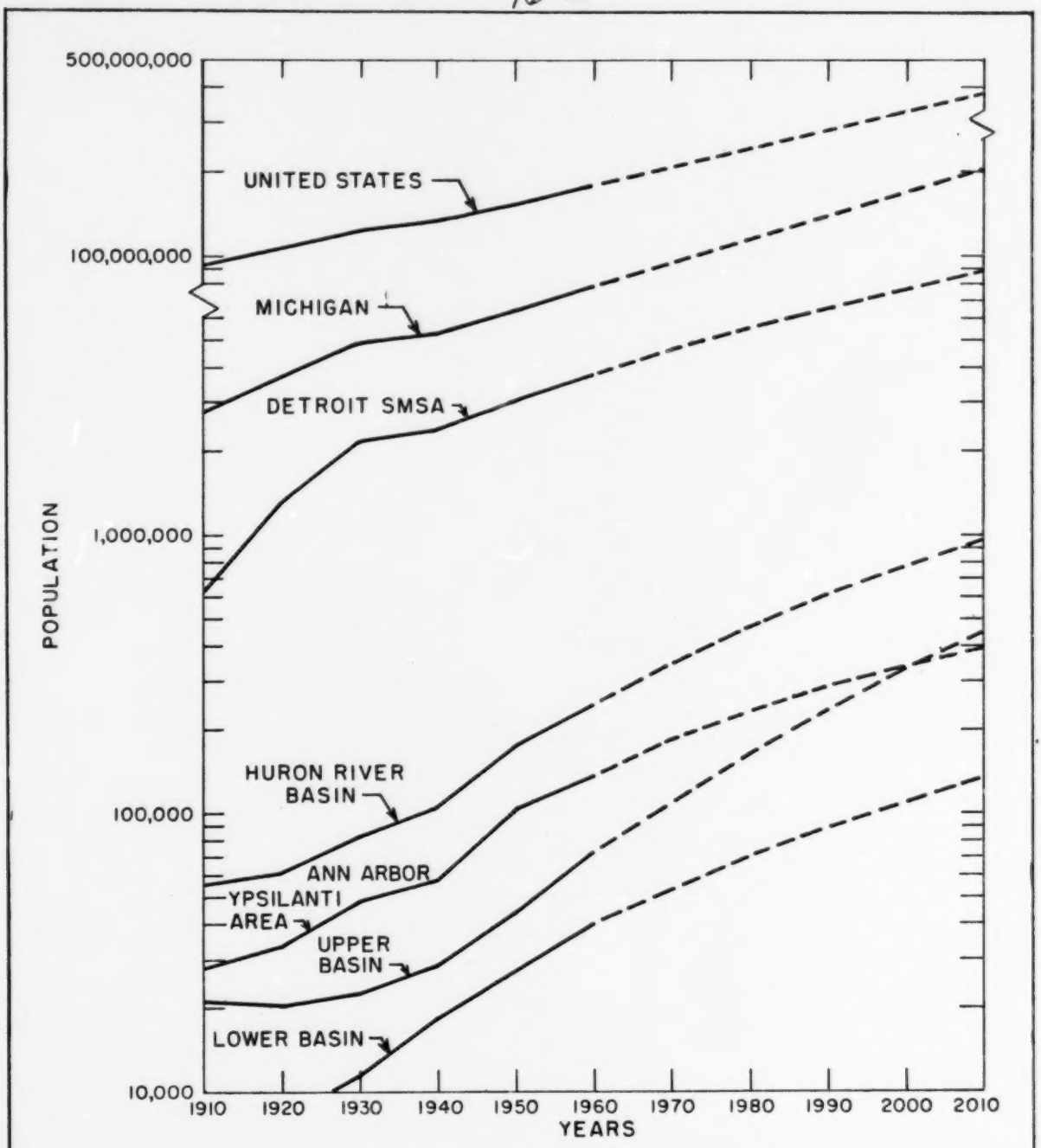
Municipality	1910	1920	1930	1940	1950	1960
Rockwood	700	800	953	1,147	1,544	2,026
Flat Rock	750	800	1,231	1,467	1,931	4,696
Belleville	486	626	758	1,286	1,722	1,921
Ypsilanti Township	1,082	1,083	2,618	4,153	14,630	25,950
Ypsilanti City	6,230	7,413	10,143	12,121	18,302	20,957
Ann Arbor	14,817	19,516	26,944	29,815	48,251	67,340
Dexter	726	587	894	1,087	1,307	1,702
Chelsea	1,764	2,079	2,268	2,246	2,580	3,355
Stockbridge	663	749	715	852	1,098	1,097
Brighton	767	800	1,287	1,353	1,861	2,282
South Lyon	615	615	844	1,017	1,312	1,753
Milford	973	1,088	1,364	1,637	1,924	4,323
Total	29,573	36,156	50,019	58,181	96,462	137,402

Table 4

Huron River Basin
Population Trends and Projections (in thousands), 1910-2010

Area		1910		1940		1950		1960		1970		1980		1990		2000		2010
U. S.	Pop.	92,228		132,165		151,326		179,323		210,000		245,000		285,000		330,000		380,000
	G.R.(1)		1.2		1.4		1.7		1.6		1.6		1.5		1.5		1.4	
Michigan	Pop.	2,810		5,256		6,372		7,823										
	G.R.		2.1		2.0		2.1											
Metro Ring(2)	Pop.	1,050		3,194		4,037		5,063										
	G.R.		3.8		2.4		2.3											
Detroit SMSA	Pop.	614		2,377		3,016		3,762		4,590		5,510		6,530		7,640		8,860
	G.R.		4.6		2.4		2.3		2.0		1.9		1.7		1.6		1.5	
Huron Basin	Pop.	56		104	(114)*	173		247		345		460		605		780		985
	G.R.		2.1		4.3*		3.6		3.4		2.9		2.8		2.6		2.3	
Ann Arbor-Ypsilanti(3)	Pop.	28		57	(67)*	102		135		183		230		285		340		395
	G.R.		2.4		4.3*		2.8		3.1		2.3		2.1		1.8		1.5	
Lower Basin(4)	Pop.	7		18		27		40		55		70		90		110		140
	G.R.		3.1		4.0		4.0		3.3		2.5		2.5		2.2		2.2	
Upper Basin(5)	Pop.	21		28		43		72		107		160		230		330		450
	G.R.		1.0		4.4		5.2		4.0		4.0		3.6		3.6		3.1	

*Corrected for change in definition of residence for college students.
(1)Growth rates are expressed in average annual (compound) percent increase.
(2)Includes the area within approximately 50-mile radius of the center of the upper basin. It includes (1) the following SMSA's: Detroit, Ann Arbor, Jackson, Lansing, Saginaw, and Flint, Michigan, and (2) the following counties: Lapeer, Livingston, and Shiawassee, Michigan.
(3)Includes the cities of Ann Arbor and Ypsilanti and the following townships: Ann Arbor, Ladi, Pittsfield, Scio, Superior, and Ypsilanti, all in Washtenaw County, Michigan.
(4)Includes Berlin Township in Monroe County and the city of Belleville and the township of Brownstown, Huron and Van Buren in Wayne County, Michigan.
(5)The upper basin is that area of the Huron River Basin not included in the Ann Arbor-Ypsilanti area or in the lower basin.



HURON RIVER BASIN REPORT

POPULATION TRENDS AND PROJECTIONS

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

REGION V — CHICAGO, ILL.

FIGURE I

VI. WATER REQUIREMENTS

Water Use and Sources of Supply

Municipal

Communities above Ann Arbor use ground water as the source of supply. From Ann Arbor downstream both surface and ground water are utilized. The municipal water supply inventory of principal communities, shown in Table 5, indicates that the average daily demand in the lower basin is about 18.2 million gallons per day, approximately one-third of which is withdrawn from the Huron River. In the Ann Arbor-Ypsilanti area the water treatment plant capacity is approximately 30 mgd, including both surface and ground water supplies.

Below Ann Arbor problems associated with treatment of surface water are primarily concerned with tastes and odors. Tastes and odors are caused by prolific algal growths that are stimulated by nutrients present in waste treatment plant effluents. As the area grows and the waste contribution to the stream increases, these algae problems may become worse and cause present sources of surface water supply to become less desirable.

Industrial

Table 6 is a summary of industrial water use in the Huron River Basin. Industrial water supplies for cooling and processing purposes total about 8 mgd; 5 mgd is taken from surface sources and the remainder from wells. Most of the industries represented in this summary are not considered large water using or "wet" industries. According to the 1958 Census of Manufactures,[6] in Washtenaw County, which comprises most of the Huron River

Table 5

Municipal Water Systems
Huron River Basin

Municipality	1960 Population	Source	Treatment	Design Capacity (mgd)	Average Demand mgd	Average Demand gpcd
Ann Arbor	67,340	70% Huron River 30% Wells	C,S,Cl, F,Cc	18.0	8.5	123
Belleville**	1,921	Huron River Wells	Fd	0.5	0.2	74
Brighton*	2,282	Wells		0.9	0.3	96
Chelsea*	3,355	Wells		1.0	0.5	172
Dexter*	1,702	Wells		1.8	0.1	95
Flat Rock**	4,696	Huron River	C,S,Cl, F,Cc	3.0	0.3	176
Milford*	4,323	Wells		0.9	0.2	51
Rockwood**	2,026	Flat Rock			0.1	48
Stockbridge*	1,097	Wells		0.4	0.1	117
Ypsilanti	20,957	Wells	C,S,Cl, F,Cc	4.0	2.9	138
Ypsilanti Twp Village Airport	 5,000 20,950	 Wells Wells	 C,S,Cl, F,Cc	 1.5 11.0	 1.0 5.2	 360
Total Huron River Wells				15.6 27.4	6.4 13.0	

C - Coagulation; S - Sedimentation; Cl - Lime Softening; F - Filtration; Cc - Chlorination;
Fd - Diatomaceous Earth Filtration.
*Communities upstream from the Ann Arbor-Ypsillanti area.
**Communities downstream from the Ann Arbor-Ypsilanti area.

Basin, there were 194 principal industries, 90 of which were involved in producing fabricated metal products and other products allied to the automobile industry. Approximately 100 of these industries are located in the Ann Arbor-Ypsilanti area and employ about 22,000 persons.

Table 6

Industrial Water Use
Huron River Basin

County	Well Water Use (mgd)				River Water Use (mgd)			
	Cooling	Processing	Other	Total	Cooling	Processing	Other	Total
Livingston	0.04	0.01	0.16	0.21	-	-	-	-
Oakland	0.12	0.58	0.34	1.04	-	-	-	
Washtenaw	0.13	0.24	0.50	0.87	1.30	3.30	-	4.60
Wayne	0.23	0.007	0.003	0.24	-	0.44	0.003	0.44
Total	0.52	0.837	1.003	2.36	1.30	3.74	0.003	5.04

Industrial water use from private sources in the Ann Arbor-Ypsilanti area is about 4.6 mgd from surface and about 1 mgd from ground sources. Most of the surface supply is taken from a low-head impoundment at Ypsilanti by a paper plant.

Hydroelectric Power

There are seven small hydroelectric installations and associated impoundments on the lower Huron River with a combined generating capacity of 11,940 KVA (see Table 7). These plants utilize a total head of 152.4 feet; the maximum head at any one plant is 33 feet. Operation of these plants alters the natural stream regimen during low flow periods in a manner not in the best interest of quality maintenance. Additional study of the effects of flow regulation on the Huron River by these impoundments should be conducted so that these impoundments can be operated so as to have the least adverse effect on water quality.

Irrigation

Since 1945, diversion of surface runoff in the basin for irrigation purposes has gradually increased. According to Table 8, a 1957 inventory[7] indicates that about 1,500 acres were irrigated. Most of the irrigated systems derive the water needs from wells and have been developed since 1945.

A recent investigation[8] of agricultural potential in the Huron River Basin found that 28,000 acres of farmland were suitable for irrigation. Some 5,000 acres of this total are riparian to the Huron. The type of farm crops most likely to be included would require annually about 28,000 acre-feet of irrigation water, with no allowances for losses in storage or transportation. Irrigation, even though presently small, is increasing, and if a large part of the total irrigable land were put to this use, it

Table 7

Hydroelectric Power Plants and Impoundments on the Huron River

River Mile	Plant	Elev. (USGS) (ft.)	Operating Head (ft.)	Generator (KVA)	Pond Area (acres)	Vol. of Pond (acre-ft)	Pond Length (ft)	Installed Wheel (hp)	Owner	Year Built
25.5	French Landing	652	32	3,600	1,425	18,377	38,000	3,200	D.E.	1925
32	Ford	685	33	2,100	1,050	16,504	20,200	2,841	F.	1932
37	Peninsular Paper	712	13.5	1,000	72	362	5,800	1,150	P.P.	1914
39	Superior	730.5	16.5	1,325	109	625	11,000	1,880	D.E.	1914
41.5	Geddes	748	16.6	1,000	292	1,242	12,750	1,200	D.E.	1919
46.5	Argo	774	15	1,125	106	542	10,670	1,150	D.E.	1913
48	Barton	799.6	25.8	1,500	310	3,600	20,900	2,065	D.E.	1915
90.5	Milford	902.5	15.5	180	66			275	F.	

D.E. - Detroit Edison Power Company; F. - Ford Motor Company; P.P. - Peninsular Paper

Table 3

Irrigation Water Supply, 1957[7&8]
Huron River Basin

Source	Number of Systems	Acres Irrigated	Percent of Irrigated Land
Ground Water	14	80	5.18
Surface Water	53	1,431	92.56
Combined Ground and Surface	6	35	2.26
Total	73	1,546	100.00

would cause considerable conflict with other water needs. However, no attempt has been made in this study to predict what part of the potential irrigation use will develop.

Recreation

Existing and planned recreational developments are of considerable importance in the watershed. The large number of scenic lakes and streams in the upper basin offer excellent opportunities for bathing, fishing, and various water-oriented sports and allied recreational pursuits. The proximity of the basin to the heavily populated Metropolitan Detroit area (presently about 4 million and estimated to reach 9 million in the next 50 years[5]) has stimulated its use for recreational purposes. Expnnding populations of

the Metropolitan Detroit area place heavy pressure on the Huron River to meet some of the recreational needs.

The Huron-Clinton Authority has invested about $5 million in parks and related recreational facilities in the lower Huron River valley[9] and contemplates substantial additional developments in the near future. The area along the Huron between Rockwood and Lake Erie is being considered for recreational improvements that are estimated to cost $6 million. Water contact recreation has been inhibited in the lower basin by water quality impairment. Recreational needs are of the utmost importance in the lower Huron and any assessment of water quality requirements should reflect these needs.

Additional Water Needs

Municipal

In the lower basin the per capita demand varies widely. Table 9 shows estimates for future per capita and daily total municipal water use based on estimated population served in the communities of the Huron River Basin.* These estimates include future industrial requirements for the light water using industries most prevalent in the basin, as well as the usual community and domestic needs.

*For example, the 2010 population of the Ann Arbor-Ypsilanti area is estimated at 395,000, whereas the estimated population served by municipal utilities (sewer and water) is 300,000.

Table 9

Future Municipal Water Supply Requirements
Huron River Basin

Municipality	1985			2010		
	Population Served	GPCD	Future Demand (mgd)	Population Served	GPCD	Future Demand (mgd)
Ann Arbor*	110,000	150	16.6	170,000	170	29.0
Belleville	3,000	100	0.3	4,800	150	0.7
Brighton	3,600	125	0.5	5,700	160	0.9
Chelsea	5,200	180	0.9	8,000	180	1.4
Dexter	2,700	125	0.3	4,200	135	0.6
Flat Rock	7,300	180	1.3	11,500	180	2.1
Milford	6,800	125	0.9	11,000	135	1.5
Rockwood	3,600	125	0.5	5,600	150	0.8
South Lyon	2,800	125	0.4	4,300	135	0.6
Stockbridge	1,700	125	0.2	2,700	135	0.4
Ypsilanti*	26,000	140	3.7	31,000	148	4.6
Ypsilanti Twp*	51,000	210	10.6	99,000	190	18.8

*Comprising the Ann Arbor-Ypsilanti area.

As previously indicated, this study places prime emphasis on conditions in the Ann Arbor-Ypsilanti area because the most serious water supply problems in the Huron River Basin are expected to occur there. Projected water supply requirements to year 2010, as shown in Figure II, indicated an average-day demand of 52.4 million gallons, and a maximum-day demand of about 90 million gallons in the Ann Arbor-Ypsilanti area. Table 10 shows the seasonal variation of projected water needs in the area. It is assumed that local storage can even out maximum-day requirements so that storage estimates can be based on average-day demands.

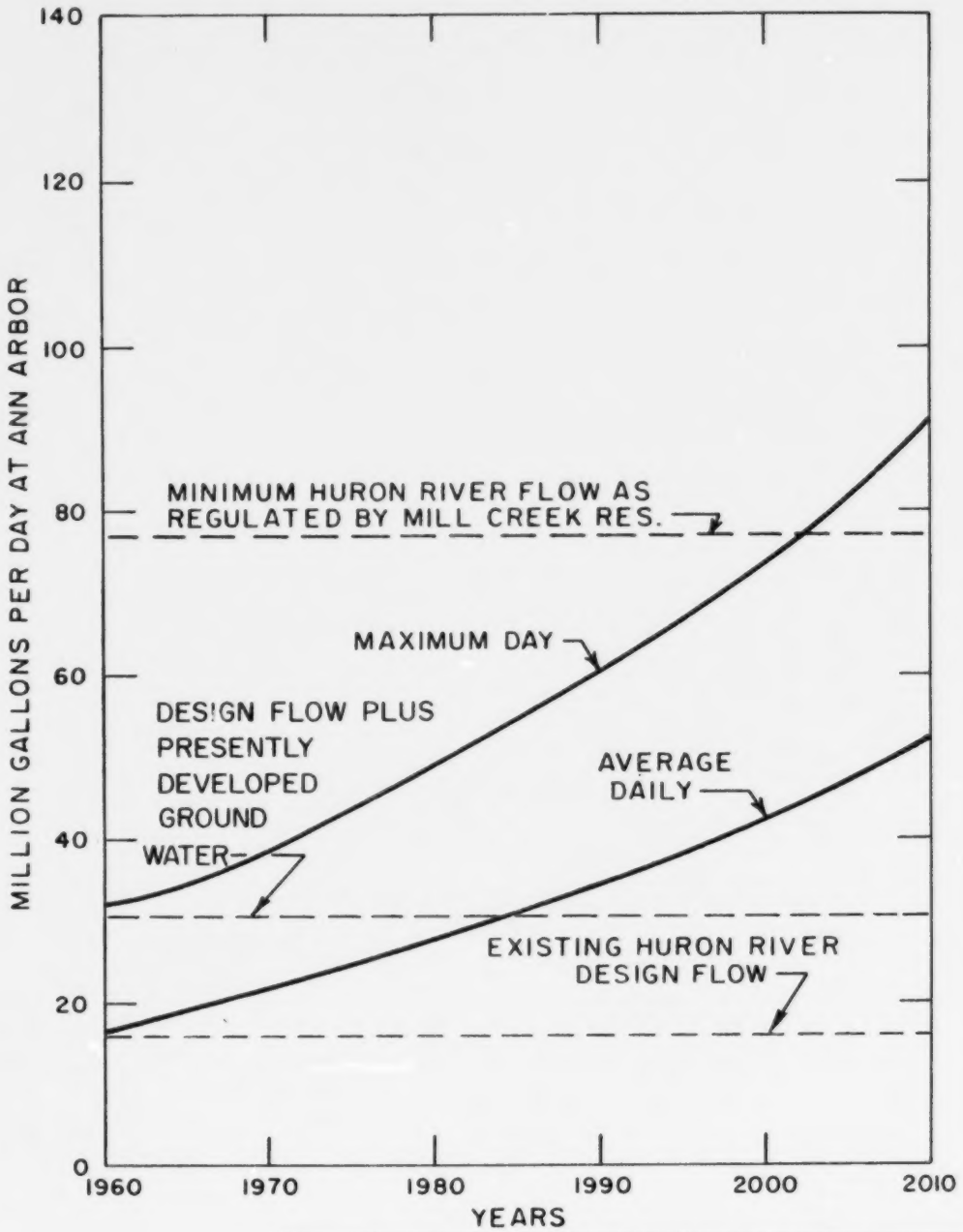
Industrial

Water for large water using industries is limited in the Lower Huron River Basin. It appears reasonable to assume that future industrial growth and expansion in the basin will be light water using industries. Therefore, only water demands of small- and moderate-sized industries have been included in per capita water use requirements.

Future Sources of Water Supply

Ground Water

Lower basin communities and industries with relatively small water demands can continue to rely on ground sources to the extent of safe yield. Present municipal and industrial ground water use in the Ann Arbor-Ypsilanti area is about 12.7 mgd. Inventories of developable ground water resources[4,10] in the immediate area indicate that an estimated 20 mgd can be developed without exceeding safe yields. The area's 2010 estimated municipal water demand of 52.4 mgd exceeds the amount that can be developed by ground water supplies alone.



HURON RIVER BASIN REPORT

WATER SUPPLY REQUIREMENTS FOR ANN ARBOR - YPSILANTI AREA

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

REGION V CHICAGO, ILL.

FIGURE II

Table 10

Seasonal Variations of Water Use
in the Ann Arbor-Ypsilanti Area

	% of Annual Average Use	Water Use in MGD 1960	1985	2010
January	90	15.8	27.8	47.2
February	92	16.2	28.4	48.2
March	89	15.7	27.5	46.6
April	87	15.3	26.9	45.6
May	100	17.6	30.9	52.4
June	113	19.9	34.9	59.2
July	124	21.8	38.3	65.0
August	118	20.8	36.5	61.8
September	108	19.0	33.4	56.6
October	96	16.9	29.7	50.3
November	90	15.8	27.8	47.2
December	92	16.2	28.4	48.2
Average		17.6*	30.9	52.4

* Municipal use only.

Surface Water

The dependable Huron River flow to meet municipal and industrial needs at Ann Arbor, as regulated by Barton Lake, is estimated to be approximately 25 cfs, or about 16 mgd. This assumes that limited drawdown of Barton Lake will be allowed by responsible State and local agencies. This source of supply is inadequate to serve the Ann Arbor-Ypsilanti area's municipal and industrial needs in 2010.

Storage in the proposed multipurpose Mill Creek Reservoir could be used to supplement existing municipal and industrial supplies. Should Mill Creek flow regulation assure 120 cfs (70 mgd) in the Huron at Ann Arbor, this source would be more than adequate to meet the estimated water supply needs of 52.4 mgd in 2010. Since existing ground and surface sources can supply a total of 36 mgd (20 mgd from wells and 16 mgd from surface sources), the additional storage to provide the 2010 needs, or about 17 mgd, could be provided by Mill Creek Reservoir and the time of first need would be about 1990.

Combined Use of Ground and Surface Supplies

The present reliable Huron River discharge, as regulated by Barton Lake, plus the estimated yield of ground water sources could supply a total of 36 mgd. This would be adequate to serve the area's municipal and industrial needs through about 1990. Additional wells would be needed

so that the Ann Arbor-Ypsilanti area would have at least 20 mgd from that source. Further withdrawal of water from the Huron River would necessitate construction of a new or enlarged water treatment plant for the Ann Arbor-Ypsilanti area and interconnection of the area's water distribution systems. This would depend on approval by appropriate State regulatory agencies.

If the area continues to rely upon water sources within the basin, beyond 1990 its additional municipal and industrial water requirements could be obtained from the proposed Mill Creek impoundment or from a single-purpose reservoir developed for municipal and industrial water supply. It is estimated that it would be necessary to withdraw about 13,000 acre-feet of storage annually to supplement the natural dependable streamflow at Ann Arbor to assure the 2010 projected municipal and industrial water supply needs for the Ann Arbor-Ypsilanti area.

Imported Water Supplies

An alternate to further development of surface and ground water sources within the basin for municipal and industrial water supplies is to procure the area's needs through the greater Detroit distribution system. Detroit's plans[11] call for an extensive water resources development program, one phase of which is to pipe water from Lake Huron. This will assure an abundant supply of high quality water for the fast-growing Detroit industrial complex. This source, plus an adequate distribution system, is being designed and developed to serve the water needs of the entire Metropolitan Detroit complex.

Municipal and industrial water supply needs of the Ann Arbor-Ypsilanti area in excess of developable ground and surface sources within the basin could be provided by the Detroit system. The value of storage in Mill Creek Reservoir is limited by the cost of the most economical solution to providing the area's basic municipal and industrial water supply needs.

Whether the Ann Arbor-Ypsilanti area should rely upon inbasin sources of supply or take advantage of the Detroit source is a question that cannot be answered immediately. This is a matter of local resolution.

It is pertinent to note that provision for water quality control must also be considered in determining whether additional water supply and quality control needs should be met by storage in the presently proposed Mill Creek Reservoir, in a single-purpose reservoir in the Huron River Basin or by purchase from the Detroit Metropolitan system.

Stream Quality Maintenance

Municipal Sources of Wastes

Treated effluents presently discharged to the Huron River from municipal waste treatment plants are equivalent in oxygen demand to untreated wastes from a community of 29,000 persons. Eighty percent of this residual waste load is discharged to a 10-mile reach of river in the Ann Arbor-Ypsilanti vicinity. Ypsilanti is the largest single contributor at this time. However, secondary waste treatment facilities are now under construction and will soon be placed in operation. Table 11 is a compilation of basic data on existing municipal waste treatment facilities in the Huron River Basin.

Table 11

Municipal Waste Treatment
Huron River Basin

Municipality	1960 Population	Population Served (1959)	Average Flow (MGD)	Treatment	Outfall River Mile	Raw BOD (lbs/day)	Effluent BOD (lbs/day)	Population Equivalent of Treated Wastes
Ann Arbor*	67,340	72,000	7.4	S,A,Cc,	46.0	14,700	550	3,300
Belleville	1,921	2,300	0.4	S	32.3	340	250	1,500
Brighton	2,282	2,900	0.2	S,F,Cc	81.9	294	44	260
Chelsea	3,355	2,900	0.3	S,A,Cc	67.1	437	115	690
Dexter	1,702	1,360	0.2	Si,Cc	66.6	170	51	300
Flat Rock	4,696	3,500	0.2	S,Cc	9.8	450	364	2,190
Milford	4,323	3,500	0.45	S,F,Cc	100.2	583	29	175
Rockwood	2,026	1,650	0.10	S,Cc	4.5	118	95	570
South Lyon	1,753	1,800	0.15	S,A,Cc	84.9	316	118	710
Ypsilanti*	20,957	21,000	2.4	S,Cc	40.5	3,600	2,300	13,800
Ypsilanti Twp*								
Village	5,000	4,000	0.9	S,A,Cc	34.5	722	181	1,100
Airport	20,950	14,400	3.8	S,A,Cc	34.5	7,300	470	2,800

A - Activated Sludge; Cc - Chlorination; S - Sedimentation; Si - Imhoff Tank; F - Trickling Filter
*Comprising the Ann Arbor-Ypsilanti area.

Industrial Sources of Wastes

Industrial surface water use along the Huron River in the immediate Ann Arbor-Ypsilanti vicinity is in excess of 3 mgd. Much of the resulting wastewater that is discharged to the Huron River is reported to be treated satisfactorily, although there are no known estimates of the total waste loads that actually reach the river. These effluents contain plating wastes, oils, paper solids including fibers, cyanides, chromium, and other chemicals.

Even though the types and quantities of present industrial waste loads are not known, reasonable allowances have been made in estimating future streamflow requirements to assure satisfactory surface water quality.

Surface Water Quality

There are no known surface water quality problems in the upper basin at this time, and according to the pattern of development, natural streamflows will be adequate through the 50-year study period. Available water quality data[3] indicate that the more serious water quality problems in the lower basin are caused by relatively large quantities of wastes reaching the stream from the Ann Arbor-Ypsilanti vicinity. Existing main stem impoundments have a marked influence on the streamflow regimen and also on the ultimate capacity of the river to assimilate wastes. Stream velocity through these impoundments is decreased, permitting deposition of suspended solids to form sludge banks below waste sources. These sludge banks are scoured and flushed downstream in the spring of the year with the usual result that the BOD is increased, especially in reaches of open stream below Ypsilanti. During and immediately after the warm low flow season, troublesome taste and

odor problems in water treatment have been reported. These problems are believed to be related to abundant algal growths that are stimulated by nutrients that usually persist in treated wastewater even after secondary biological treatment.

At present, wastes from the Ann Arbor-Ypsilanti area amount to 26,000 pounds of 5-day, 20°C. BOD per day prior to treatment. After treatment at the four municipal waste treatment plants serving the area, about 3,500 pounds of BOD still remain in the effluents, all of which are discharged to the Huron River. This will be reduced to about 2,000 when adequate control is provided for all wastes. This oxygen demanding load is equivalent to that of raw sewage from a city with a population of about 12,000 persons.* The impact of this amount of waste on the quality of the Huron River waters varies with the streamflow and water temperature. During the warm season when streamflows drop as low as 30 cfs, the river is capable of assimilating about one-third of the present wastes on a point loading basis without seriously degrading the water quality.

One of the primary purposes of this study is to determine the need for flow regulation in the Huron River for quality control purposes. In order to assess this need properly, river water quality objectives should be considered.

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*There are insufficient data available on waste loads discharged by industries with separate outfalls to establish their contribution to the stream. Therefore, it is assumed that with adequate treatment, or other means of controlling waste at the source, industrial wastes reaching the river have been adequately considered.

Water Quality Objectives

For the specific uses to which a stream may be put it is necessary to consider a wide range of quality parameters. In a stream such as the Huron River, subject to substantial nutrient loads and having shallow impoundments, it is difficult to separate the many factors affecting water quality and specify limits for each parameter. Flow requirements for water quality control have therefore been selected, for this study, in terms of maintaining an acceptable level of dissolved oxygen in the stream. It is generally accepted that in order to maintain a minimum level of fish and aquatic life in a warm water stream, at least 4 mg/l of dissolved oxygen should be maintained. Storage requirements for water quality control have been based on assuring sufficient flow to maintain 4 mg/l in 9 out of 10 years. In years having even lower flows, it is to be anticipated that the dissolved oxygen level will fall somewhat below the objective.

Streamflow Regulation

As communities in the Huron River drainage basin grow, become more urbanized, and use greater quantities of water, it will become increasingly difficult to maintain acceptable water quality in the stream. As shown in Figure II, a population of 260,000 is expected in the Ann Arbor-Ypsilanti area by 1985 and over 395,000 by 2010. Waste loads ordinarily associated with these populations, with suitable adjustments for industrial growth and after provision of adequate treatment as required under Public Law 87-88, have been analytically routed through the stream system in order to estimate streamflow requirements to maintain the minimum D.O. water quality objective.

Adequate waste treatment is presumed to be equivalent to the effectiveness of well-operated, secondary biological treatment plants. However, uncollected wastes and storm water overflow increase the total load on the stream. For estimating purposes, it is assumed that the total organic waste load reaching the Huron River from this critical area can be reduced 85 percent as measured by the standard 5-day BOD test. Based on organic waste loadings estimated to originate in the Ann Arbor-Ypsilanti area, including both municipal and industrial sources of waste and after provision of adequate treatment, flows up to 120 cfs will be required in 1985 and 200 cfs in 2010. These flows represent the more critical requirements during the month of July when temperatures are highest; lesser streamflows are permissible during cooler months of the year, as indicated by typical flows shown in Table 12.

Deficiencies in natural flow of the Huron River to meet this schedule at Ann Arbor were found to occur in months between June and October when examined on the basis of average monthly streamflow. These monthly flow deficiencies were arrayed on an annual basis covering 55 years of record to determine the required draft on upstream storage to meet the flow schedule. Analysis indicates that in 40 percent of the years it would have been necessary to draw on storage to meet the estimated 1985 needs and in 85 percent of the years, to meet the 2010 needs. Also that for 90 percent of the years the draft on storage would not exceed 6,000 A.F. to meet the 1985 flow schedule and 20,000 A.F. for the 2010 schedule. The storage draft calculated from the mean monthly flows (as shown on Table 12) has been increased 20 percent to cover such items as synchronization of reservoir releases for downstream needs, conveyance losses, and other unforeseen requirements.

Table 12

Flow Requirements for Quality Control Purposes
Huron River at Ann Arbor

Month	Monthly Mean Air Temperature (°F)	Monthly Mean Flow (cfs) 1934*	Typical Minimum Flow Requirements (cfs) 1985	2010	Draft on Storage (acre-ft.) 1985	2010
January	26.4	235	38	63	-	-
February	26.0	145	38	63	-	-
March	34.8	189	43	72	-	-
April	46.6	990	56	94	-	-
May	58.6	211	70	107	-	-
June	68.8	72	100	167	-	1,300
July	73.3	31.5	120	200	1,310	6,000
August	71.4	21.1	112	187	2,620	6,500
September	63.9	55.8	90	150	1,070	3,200
October	52.7	71.6	67	112	-	-
November	39.3	109	46	77	-	-
December	28.8	123	38	63	-	-
		Avg.	67	113	Total 5,000	17,000

*Year of lowest summer flows of record.

In a study conducted by the Michigan State Water Resources Commission in 1957,[8] several impoundment sites in the basin were investigated for flow regulation potential. It was pointed out in that study that "...the practical utility of the river for water supply and waste disposal is seriously limited except as provision can be made for supplementing the natural low flow with releases from reservoirs." And further, "Whether it will be feasible to develop any reservoirs and, if so, how many and which ones, are questions to be answered by comparing their costs and capabilities with those of alternative facilities." The subject study reported on six possible reservoir sites, most of which are in the upper basin. Combined, these sites would control drainage from 364 square miles, or approximately 40 percent of the total basin area. It was estimated that a total storage capacity of 62,750 acre-feet could be developed. Thus streamflow regulation would be possible if acquisition of reservoir sites is accomplished before extensive development takes place.

In addition to flow regulation, the area's secondary waste treatment facilities must be periodically enlarged to keep abreast of the constantly increasing quantities of wastewater that must be adequately treated prior to discharge in order to meet and maintain desirable river water quality conditions.

Wastewater Interception

Wayne County has proposed to modify its present plans for constructing sanitary interceptor sewers to provide some capacity for Washtenaw County municipalities. The Wayne County interceptor would be enlarged and extended to the Washtenaw County line. Communities within Washtenaw County would

then extend this interceptor from the county line westerly to intercept wastewater outfalls that presently discharge to the Huron River. These communities would contract for flowage capacity in the interceptor and for treatment costs. Wayne County has an existing waste treatment plant on the Detroit River at Wyandotte, Michigan, and plans call for enlarging this plant as an intermediate step in the regional sewage transmission and treatment plan.

Withdrawal of water supplies from the now unregulated Huron River and discharge of the resulting wastewater to the Wayne County interceptor sewer system would reduce the streamflow by the magnitude of the diversion. In 2010, if the Ann Arbor-Ypsilanti area were to derive its municipal and industrial water supplies from ground and surface sources within the basin, up to 50 cfs of surface water supply would be needed. This is twice the yield of the Huron River when the present natural streamflow is assessed in terms of dependability for municipal and industrial water supply purposes. Use of the stream to this extent would frequently result in essentially no flow during summer seasons. This demonstrates the need for storage for flow regulation purposes in the case of wastewater diversion. This also emphasizes the need for maintaining a minimum flow regulation schedule at Ann Arbor in the event of wastewater diversion of basin-oriented water supplies.

Wastewater interception would prevent waste treatment effluents from reaching the stream system but would not eliminate various sources of natural and uncontrollable wastes such as storm water overflow that are difficult

to intercept. These wastes would continue to reach the stream and require some sustained flow for water quality maintenance, or the area would still suffer substantial reduction in many legitimate uses of the stream below the Ann Arbor-Ypsilanti area.

As previously indicated, waste treatment plant effluents contain large quantities of nutrients which are particularly troublesome in the Huron River. Waste interception would reduce this source of nutrients but it is estimated that 5 to 10 percent of the total waste load from the area will continue to reach the stream. This would require additional upstream storage to maintain adequate water quality based on a typical minimum flow schedule in 2010, as follows:

Month	Minimum cfs	Month	Minimum cfs
January	25	July	80
February	25	August	75
March	29	September	60
April	38	October	45
May	43	November	31
June	67	December	25

Average 45 cfs

By 2010 provision of quality control storage to allow a draft of 9,000 acre-feet would be required to meet the preceding flow schedule in a critical year.

If water supplies for municipal and industrial purposes were imported to meet the 2010 needs, and the resulting wastewater discharged to the Huron River, natural streamflow would be augmented to the extent of the imported

water supply thereby reducing the difference between required and available flows and the amount of storage required for quality control purposes. Should the imported supplies be diverted to interceptor sewers after use, the waste load would be reduced but minimum flows listed above would still be needed. Since the natural streamflow not diverted from the basin would be available for quality control purposes, storage needs for quality control purposes would be reduced still further. It is estimated that with importation of municipal and industrial water supplies and interception of wastes, sufficient storage to allow a draft of 6,000 acre-feet should be provided to meet downstream quality control requirements.

The foregoing analysis indicates that provision for storage for quality control will become necessary within the design period with any of the possible plans for Huron River water resources development.

VII. ALTERNATE PLANS AND BENEFITS OF STORAGE

The basic alternative plans for water supply and quality control considered in this study are illustrated in Figure III. The figure indicates that for each source of water supply considered there are two methods to care for the resulting waste water and still realize surface water quality objectives. It should be further noted that it is not necessary that any one method be pursued to the total exclusion of the others.

Plan A involves the combined use of both ground and surface sources within the Huron River Basin to provide for municipal and industrial water supply needs in the critical Ann Arbor-Ypsilanti area. It has been previously determined that the 2010 estimated water needs for this area is 52.4 mgd on an average annual basis. About 20 mgd of this could be provided from ground sources and the remainder, or 32.4 mgd, from surface sources. It is estimated that the Huron River, as regulated by Barton Lake, can be relied upon to supply 16 mgd for water supply purposes. Additional upstream storage sufficient to allow about 13,000 A.F. to be withdrawn annually would be needed to regulate Huron River streamflow to meet the additional needs anticipated through 2010, and this quantity is also used to approximate the size of a reservoir to yield this draft. It is estimated a single-purpose reservoir adequate for this purpose could be provided in the Huron River Basin above Ann Arbor for $2,800,000. Since the time of first need is about 1990, this cost has been discounted at 3 percent to a present worth, then amortized at 4 percent over the 50-year project life, resulting in an annual benefit of $76,000, including operation and maintenance.

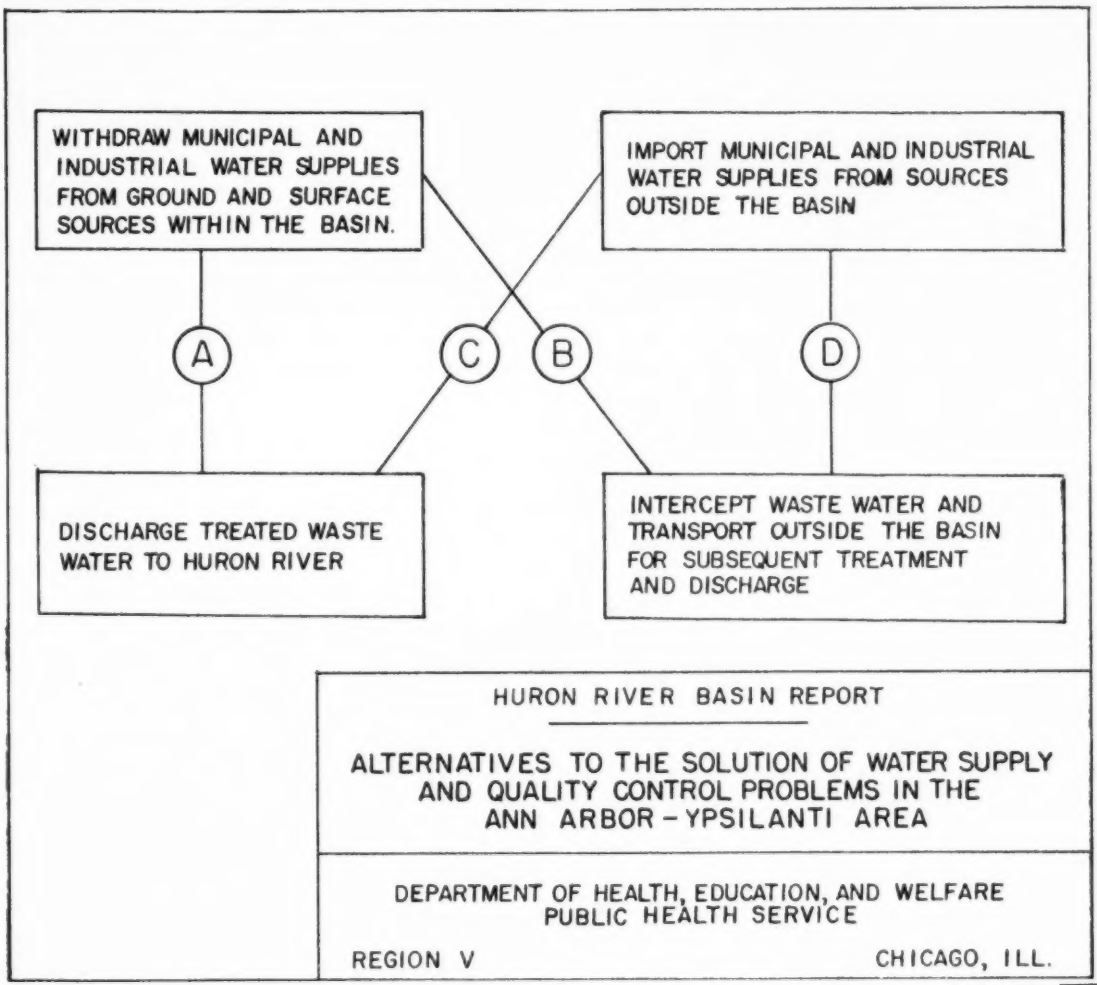
WITHDRAW MUNICIPAL AND INDUSTRIAL WATER SUPPLIES FROM GROUND AND SURFACE SOURCES WITHIN THE BASIN.
IMPORT MUNICIPAL AND INDUSTRIAL WATER SUPPLIES FROM SOURCES OUTSIDE THE BASIN
A
C
B
D
DISCHARGE TREATED WASTE WATER TO HURON RIVER
INTERCEPT WASTE WATER AND TRANSPORT OUTSIDE THE BASIN FOR SUBSEQUENT TREATMENT AND DISCHARGE
HURON RIVER BASIN REPORT
ALTERNATIVES TO THE SOLUTION OF WATER SUPPLY AND QUALITY CONTROL PROBLEMS IN THE ANN ARBOR - YPSILANTI AREA
DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILL.

FIGURE III

In Plan A it is assumed the resulting treated wastewater would be discharged to the Huron River at one or more points within the Ann Arbor-Ypsilanti area. As previously shown, this would require about 20,000 A.F. of draft on storage to maintain stream quality by 2010. The single-purpose reservoir alternative cost method to approximate benefits was employed. In this case the single-purpose reservoir with capacity to permit an annual draft on storage of 20,000 A.F. was estimated to cost $3,500,000. Amortized for 50 years at 4 percent interest, the value of the benefit is estimated to be at least $193,000 per year, including operation and maintenance. On this basis the total benefit value in Plan A for the provision for both municipal and industrial water supply storage, plus flow regulation storage for quality control purposes, is estimated at $269,000 annually.

Plan B assumes the area's water supplies will continue to be derived from inbasin sources as in Plan A, but differs from Plan A in that the resulting wastewater would be intercepted and discharged after treatment outside the basin. Streamflow would be reduced to the extent of the water supplies withdrawn and would leave the stream deficient in flow during most summer seasons when assessed in terms of quality control. Even with diversion of treated wastewater from the stream, there will be uncollectable wastes and storm water overflow which will require dilution and hence flow regulation in order to realize reasonable surface water quality for all downstream water users. It is estimated that additional upstream storage adequate to permit an annual draft of 9,000 A.F. will be needed by 2010. The cost of such a reservoir in this area is estimated at $2,225,000 and the associated operation and maintenance is estimated at about $20,000

per year. By the method previously used the minimum annual value of the benefit is $124,000. On this basis the total benefit in Plan B for provision for both municipal and industrial water supply storage plus flow regulation storage for quality control is estimated at $200,000 annually.

Plan C involves the importation of water supplies from the city of Detroit water system. Many of the suburban and outlying communities in the Detroit Metropolitan Region have seriously considered the Detroit source at one time or another. Should the communities in the Ann Arbor-Ypsilanti area elect to obtain additional water supplies from the Detroit system, extension of the Detroit distribution system to the area and probably an agreement to purchase a minimum amount of water would be required. This would eliminate the need for additional storage in the Huron River Basin for water supply purposes.

In Plan C, it is assumed that the treated wastewater from the area would continue to be discharged to the Huron River. The importation of water from Detroit and subsequent discharge to the Huron River would in fact amount to an augmentation of the streamflow. This would reduce the amount of upstream storage required for quality control purposes, but would still require additional reservoir capacity adequate to permit an annual draft of 12,000 acre-feet. A single-purpose reservoir of this capacity is estimated to cost $2,700,000. Allowing for $23,000 of operation and maintenance cost, the resulting minimum annual value of the benefit for its provision for water quality control would be $148,000.

Plan D involves the combination of importation of water supplies and interception of the wastes with discharge outside the Ann Arbor-Ypsilanti area. Both of these aspects have been covered in previous plans considered. Plan C considered the importation of water supplies and in which case no need was found for additional inbasin storage for municipal and industrial water supply, since the Detroit system could be made adequate to supply the needs of the area. Plan B considered the interception of wastewater.

Plan D assumes the Wayne County sewage interceptor system could be made adequate to serve the area but, as covered in Plan B, wastewater interception would not completely eliminate the need for storage above Ann Arbor for quality control purposes. While storage needed would be reduced, a reservoir of sufficient size to permit an estimated 6,000 A.F. of draft on storage will still be needed to meet the 2010 needs for quality control purposes. Again, using the annual draft on storage requirements to approximate the size of a single-purpose reservoir to yield this amount of draft, the estimated capital cost is $1,800,000. The value of the benefits for its provision would be $100,000 annually, including $16,000 per year for operation and maintenance.

From the foregoing, it is clear that there are alternative methods of providing both water supply and stream quality control. The area either in whole or in part has, at one time or another, attempted to evaluate the relative merits of these plans, but to date no clear-cut, long-range plans have as yet evolved. Regardless of the plan or combination of plans, the

multipurpose use of the Huron River should be protected for all legitimate water users. Within the limits of the study period to 2010, a need for storage has been found in each of the four alternative plans considered. Therefore, regardless of the plan which may be followed, there will be need for storage, although the amount needed and hence the benefits that will be realized will vary, depending on the plan adopted.

An objective economic analysis may not necessarily reveal the more desirable course or best long-range plan. As the Ann Arbor-Ypsilanti area becomes more urbanized and more closely identified with the Detroit Metropolitan Region the practice of discharging wastewater to the Huron River will no longer be reasonable. As the population of the area expands and recreational use becomes more intense, the need for streams of good quality also increases. The fact that there is an alternate means available to the area whereby it would no longer be necessary to discharge wastes to the Huron River may result in the selection of a more expensive solution because of the aesthetic values which can be realized.

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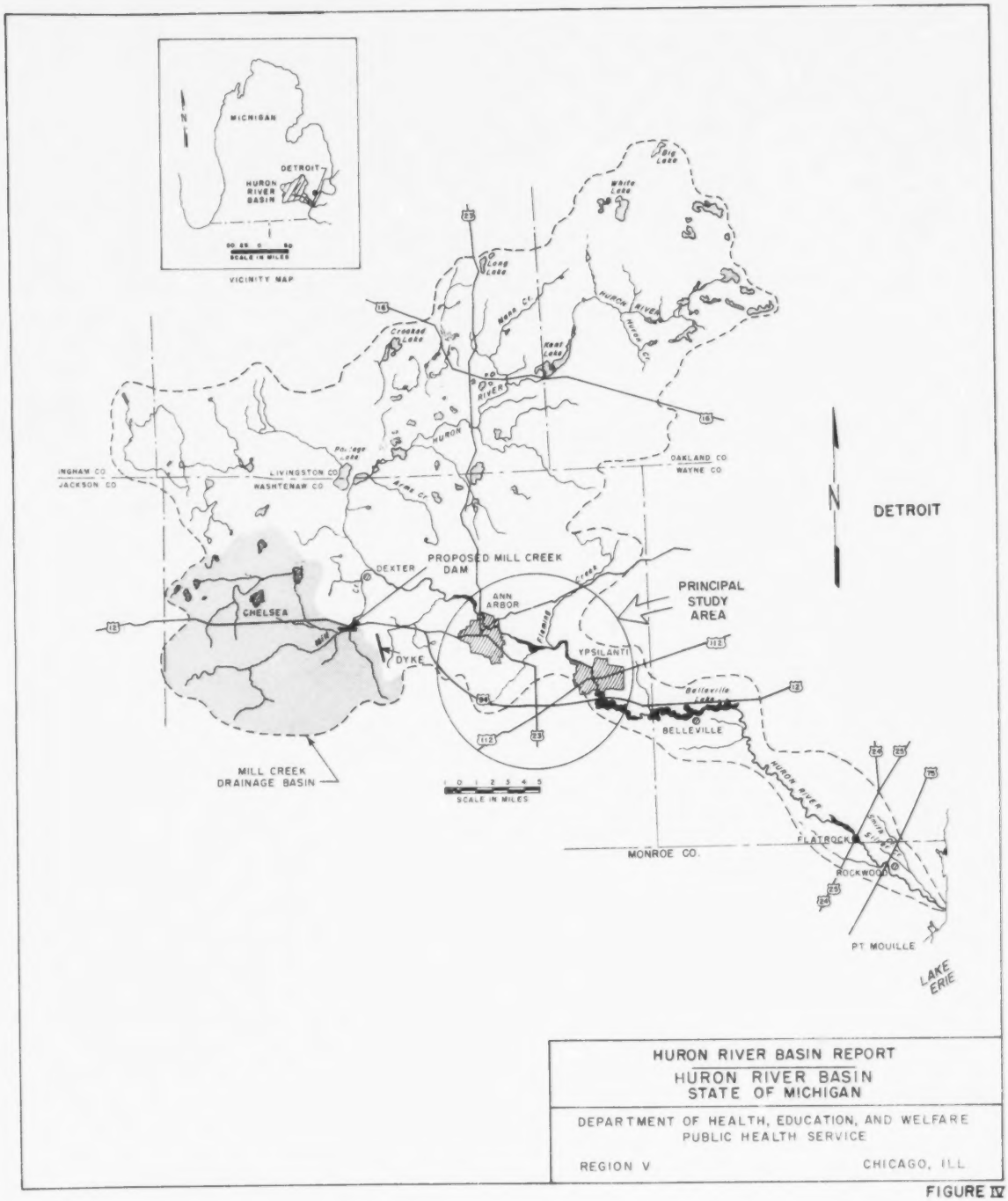

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

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FIGURE IV